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(54) Liquid cooling type high frequency solid state device arrangement.

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(73) Proprietor: **FUJITSU LIMITED**
1015, Kamikodanaka Nakahara-ku
Kawasaki-shi Kanagawa 211 (JP)

(72) Inventor: **Saito, Toshiyuki**
71-1-414, Nogawa Miyamae-ku
Kawasaki-shi Kanagawa 213 (JP)
Inventor: **Okubo, Naofumi Raionzu Manshon**
Miyamaedaira
Dai 2-404, 585-1 Mukaigaoka Miyamae-ku
Kawasaki-shi Kanagawa 213 (JP)
Inventor: **Kaneko, Yoshiaki Fujitsu Dai 1**
Fujigaoka-ryo 416
23-10, Umegaoka Midori-ku
Yokohama-shi Kanagawa 227 (JP)
Inventor: **Tokumitsu, Yasuyuki**
2-12-14, Numame
Isehara-shi Kanagawa 259-11 (JP)

(74) Representative: **Lehn, Werner, Dipl.-Ing. et al**
Hoffmann, Eitle & Partner Patentanwälte
Arabellastrasse 4
D-8000 München 81 (DE)

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Description

The present invention relates to a liquid cooling arrangement utilizing boiling a coolant for cooling high frequency solid state device, such as an amplifier or an oscillator, which comprises a heat generative semiconductor chip, such as a transistor or a diode, e.g. for microwave or millimeterwave. Such a device is known from FR-A-1 266 244.

A known high frequency solid state device is cooled by a liquid boiling type cooling system in which a liquid coolant is used as a cooling medium. The coolant is heated and boiled by the heat of the solid state device and evaporated to produce vapor bubbles, thereby the heat of the solid state device being absorbed. The vapor is condensed to liquid and re-used as the coolant.

In the liquid cooling system of the prior art, the semiconductor solid state chip secured on the mount of the solid state device and is covered by a cap. Provided the chip is not directly exposed to the coolant the influence of the change of dielectric constant of the coolant due to the temperature change thereof can be reduced, so that the frequency characteristic of the solid state chip is not greatly changed. However, the vapor bubbles generated in the boiling process of the coolant cause unstable change of the dielectric constant thereof, which causes noise of frequency from 0 Hz to 100 Hz along with amplitude modulation of the solid state device due to the noise. Also, waves leaked from the circuit of the solid state device are reflected by the bubbles or liquid surface and back to the solid state circuit, which causes amplitude modulation thereof. Besides, the film boiling phenomenon occurs over a limited surface in contact with the solid state chip, which reduces the heat radiation from the chip.

The present invention was made in view of the above points.

An object of the present invention is to provide a liquid cooling system by boiling coolant for cooling a high frequency solid state device, in which amplitude modulation of the solid state device is minimized to stabilize the frequency characteristic thereof.

The object is achieved according to the present invention, by a liquid cooling type high frequency solid state device arrangement comprising a solid state chip; at least one matching circuit connected to said solid state chip; a carrier for mounting said solid state chip and said matching circuit, constituting a solid state device to be cooled; a coolant vessel for containing a liquid coolant, a space for coolant vapor remaining at the top thereof; and a means for condensing said coolant vapor contained in the top space of said vessel, heat radiation means having a surface area in contact with said liquid coolant considerably greater than area of said chip and being in contact with at least a part of said solid state device for boiling and evaporating said coolant, and electromagnetic wave leakage suppression means.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a constructional view of an embodiment of the present invention;

Figure 2 is a perspective view of an example of the solid state device in accordance with the present invention;

Figures 3, 4, 9, and 10 are constructional views of variations of the solid state device in accordance with the present invention;

Figure 11 is a partial sectional view along the line A-A' of Fig. 10;

Figure 12 is a perspective view of another example of the solid state device of the present invention;

Figure 13 is a circuit diagram of the solid state device of Fig. 12;

Figure 14 is a perspective view of further example of the solid state device of the present invention;

Figure 15 is a sectional view of the solid state device of Fig. 14;

Figure 16 is a perspective view of variation of the solid state device of Fig. 14;

Figure 17 is an upper view of further example of the solid state device of present invention;

Figure 18 is a sectional view of the solid state device of Fig. 17;

Figure 19 is an upper view of a variation of the solid state device of Fig. 17;

Figure 20 is a sectional view of the solid state device of Fig. 19;

Figure 22 is still another embodiment of the present invention;

Figure 23 is a partial constructional view of a variation of the embodiment of Fig. 22;

Figure 24 shows a variation of the solid state device of Fig. 22, Figure 24(a) representing a longitudinal section thereof and Figure 24(b) representing a transverse section thereof;

Figure 25 is a sectional view of a variation of the embodiment of Fig. 22;

Figure 26 is a partial sectional view of another variation of the embodiment of Fig. 22;

Figure 27 is a constructional view of an arrangement of a plurality of solid state devices in accordance with the present invention;

Figure 28 is a perspective view of another arrangement of a plurality of solid state devices in accordance with the present invention;

Figure 29 is a constructional view of still another arrangement of a plurality of solid state devices in accordance with the present invention;

Figure 30 is a sectional view of the structure of Fig. 29;

Figure 31 is a partial constructional view of further arrangement of a plurality of solid state devices in accordance with the present invention;

Figure 32 is a vertical sectional view of further arrangement of a plurality of solid state devices in accordance with the present invention;

Figure 33 is a horizontal sectional view of the structure of Fig. 32; and

Figure 34 is an upper view of the structure of Fig. 32.

Each of the embodiments shown in Figures 5, 8 and 21 as such falls outside the scope of the invention as claimed.

An embodiment of the present invention is illustrated in Fig. 1. A liquid coolant 2 having a low boiling point, such as solution of Freon, (Regd. Trade Mark) or carbon tetrafluoride is contained in a vessel 1, a space 49 for vapor of the coolant 2 remaining at the top thereof. The vessel 1 is sealingly covered by an upper plate 3 which has cooling fins 4 on the outer side thereof. A high frequency solid state device 24, such as an amplifier, is dipped in the coolant 2. The solid state device 24 is connected to a coaxial cable 11 via a coaxial connector 10 at each end thereof. The coaxial cable 11 is connected to coaxial cable 13 from outside via a coaxial connector 12 secured to the upper plate 3. The solid state device 24 comprises a semiconductor device 5 comprising a heat generative semiconductor chip 8 such as a field effect transistor (FET) and matching circuit devices 6 disposed on both sides of the semiconductor device 5, to adjust the impedance of the semiconductor chip 8 with the outer cables. The semiconductor device 5 and the matching circuit devices 6 are mounted on a metallic carrier 7. The carrier 7 is installed within a box 70, as is illustrated in Fig. 2. The bottom plate of the box 70 may be thick to serve as the carrier, thereby enabling the box 70 to be formed as one unit integral with the carrier 7. The semiconductor chip 8 is secured to a metallic mount 15. The matching circuit device 6 comprises a dielectric plate 80 and a matching circuit pattern 20 formed by strip lines on the dielectric plate 80 and connected to the connector 10 on one end and the semiconductor chip 8 of the semiconductor device 5, on the other end. The semiconductor chip 8 is disposed within a recess 9 formed in the carrier 7. The mount 15 of the semiconductor chip 8 covers and seals the recess 9. In a preferred example of the semiconductor device, as is illustrated in Fig. 3, the semiconductor chip 8 is sealed by a ceramic package 16 which is coated by a wave absorber layer 17 comprising, for example, ferrite or carbon to minimize the effect of noise waves and to prevent leakage of waves from the chip.

The function for cooling the heat generative semiconductor chip 8 is as follows. The heat of the semiconductor chip 8 is transferred to the liquid coolant 2 through the mount 15 and the coolant 2 is heated to its boiling temperature. The coolant 2 boils and generates vapor bubbles 14, due to the evaporation of the liquid coolant, absorbing heat from the semiconductor chip 8. The vapor of the coolant fills the top space 49 of the vessel 1. The heat of the vapor is discharged through the cooling fins 4 of the upper plate 3. Thereby, the vapor is condensed and drops as liquid coolant.

The semiconductor chip 8 of the above-mentioned solid state device 24 is arranged to be hindered from coming in direct contact with the liquid coolant 2, by disposing the chip mount 15 between the liquid coolant and the chip 8 in a manner that the chip 8 is disposed and sealed in the recess of the carrier 7. Therefore, the semiconductor chip 8 is not influenced by vapor bubbles 14 which cause amplitude modulation of the solid state device 24 and the frequency characteristic of the semiconductor chip 8 is stabilized irrespective of the change of the dielectric constant due to the coolant temperature change. Also, the problem of destruction of the chip 8 due to the film boiling around the chip surface is obviated. The amplitude modulation of the matching circuit is also minimized with this structure.

A radiator 19 having fins may be attached to the mount 15 of the semiconductor device 5, as illustrated in Fig. 4, to enhance the efficiency of cooling the semiconductor chip 8.

Fig. 5 represents another example of the solid state device 24. In this example, the solid state device 24 comprises a cover 22 which covers one entire surface of the carrier on which surface the semiconductor device 5 and the matching circuit devices 6 are mounted. The solid state device 24 is dipped in the liquid coolant 2 in such a manner that the rear surface (on which the semiconductor device 5 and the matching circuit devices 6 are not mounted) of the carrier 7 is disposed on the upper side so that the vapor bubbles are generated in the upper side of the solid state device 24 and smoothly move upward. Cooling effect is enhanced by attaching a radiator 21 on the carrier 7.

Fig. 6 represents a variation of the solid state device 24 of Fig. 5. In this example, an opening 23 is formed in the carrier 7 at the location behind the semiconductor chip 8. The radiator 21 is attached directly to the rear side of the mount 15 of the semiconductor chip 8. Cooling effect is further enhanced when compared with the example of Fig. 5. In the examples of Figs. 5 and 6, the radiator 21 may be omitted.

Another embodiment is illustrated in Fig. 7. A package type semiconductor device 5 is mounted on the carrier 7. The semiconductor chip 8 is mounted on the mount 15 and sealingly enclosed by a package 30, forming a space 30a between the package 30 and the semiconductor chip 8. A radiator 31 comprising fins 31b attached to a pillar 31a is disposed on each side of the package 30 on the mount 15. With this construction, when the semiconductor device 5 is dipped in the liquid coolant, the semiconductor chip 8 does not come in direct contact with the liquid coolant. Therefore, amplitude modulation can be prevented similarly as the case of example of Fig. 1.

Fig. 8 represents a variation of the example of the semiconductor device of Fig. 7. In this example, the package 30 is covered by a metallic block 32 for shielding wave radiation from the solid state chip. Fins 33 are formed on the block 32 for radiating heat from the semiconductor device 5.

Fig. 9 represents a variation of the semiconductor device of Fig. 8. A wave absorber 34 is disposed on the package 30 to absorb waves leaked from the semiconductor device 5 and prevent the leaked waves from being reflected back toward the semiconductor device 5, thereby preventing amplitude modulation.

Another embodiment of the present invention is illustrated in Figs. 10 and 11. In this example, the matching circuit device 25 is formed in a triplate structure. The matching circuit pattern 20 is formed between two dielectric layers 26 and 27. Conductive layers 28 and 29 are coated on the upper and lower surfaces of the assembly of the two dielectric layers 26 and 27. Such a triplate structure stabilizes the impedance of the matching circuit irrespective of change of ambient temperature and ambient dielectric constant. By using such a matching circuit, amplitude modulation can be minimized.

Another example of the solid state device in accordance with the present invention is illustrated in Fig. 12. Fig. 13 is a circuit diagram of the solid state device of Fig. 12. In this example, the matching circuit is formed as a lumped elements type matching circuit 35. The semiconductor device 5 comprises an FET 8 as the semiconductor chip. The FET 8 comprises a gate (G), a source (S) and a drain (D). The matching circuit 35 comprises two chip capacitors 36a and 36b, a capacitor 36c for blocking DC, a wire 38 for biasing DC, and inductors 37a and 37b, as illustrated in Fig. 13. The impedance of the lumped elements type matching circuit 35 is stable irrespective of change of ambient temperature and ambient dielectric constant. By using such a matching circuit, amplitude modulation can be minimized.

Another example of the solid state device in accordance with the present invention is illustrated in Figs. 14 and 15. The carrier 7 comprises a mount 40 in the center thereof and radiator blocks 39 on both sides of the mount 40, projecting higher than the mount 40. The mount 40 and the radiator blocks 39 are formed as one body with the carrier 7. The semiconductor chip 8 is directly mounted on the mount 40. Two parallel metallic bars 41 having a rectangular cross section are disposed on both edges of the carrier 7 along the strip line pattern 20 of the matching circuit device 6. The metallic bars 41 are arranged to prevent the leakage of waves from the matching circuit. Width W between the two bars 41 is equal to the so called cut-off dimension which is determined according to the functional frequency of the matching circuit and the ambient dielectric constant. A recess 42 for receiving the radiator 39 is formed in each bar 41.

The solid state device 24 having the above-mentioned construction is dipped in a liquid coolant. Heat of the semiconductor chip 8 is discharged through the radiators 39 to the coolant. Therefore, the vapor bubbles of the coolant are generated mainly around the radiators 39 and the bubbles generated on the chip surface are reduced. The amplitude modulation due to the bubbles is minimized, accordingly. Besides, wave leakage from the matching circuit is prevented by the function of the two metallic bars 41 disposed in parallel and apart from each other by the distance of the cut-off dimension. Therefore, the amplitude modulation due to the waves leaked from the matching circuit and reflected by the vapor bubbles or the liquid surface is prevented.

Fig. 16 represents a variation of the solid state device of Fig. 14. In this example, cooling fins 43 are formed instead of the radiator block 39 of Fig. 14 to enhance the cooling efficiency and further reduce the bubbles generated on the chip surface.

Another variation of the solid state device is illustrated in Figs. 17 and 18. In this example, the semiconductor chip 8 is directly mounted on the upper plane surface of a rectangular parallel piped carrier 44. Side walls 45, which serve as the radiator 39 and the parallel metallic bars 41, are disposed on both edges of the carrier 44. The width W between the walls 45 is equal to the cut-off dimension. The height of the walls 45 is determined, according to the semiconductor chip to be used, by experiment for example, considering the required cooling effect and wave leakage prevention effect. End walls 43 are disposed to enhance the wave shield effect.

Another variation of the solid state device in accordance with the present invention is illustrated in Figs. 19 and 20. In this example, the width between the two parallel side walls 41 is widened at the portion of the semiconductor chip 8 for a smooth upward movement of bubbles. The cut-off dimension is usually less than one half of the wavelength of frequency used in the circuit. Therefore, the width W become very small when the frequency is very high, so that the bubbles do not smoothly move upward. For a smooth upward movement of the bubble, the gap between the two walls 41 is desirably five times as wide as the diameter of the bubble (about 0.2 mm). Therefore, if the cut-off dimension is less than about 1 mm, the width W_1 (Fig. 20) of the gap between the walls 41 at the portion of semiconductor chip 8 is widened. Other constructions, functions and effects of this example are substantially the same as those of the example of Fig. 17.

Another embodiment is illustrated in Fig. 21. In this example, an opening 47 is formed in the bottom plate of the vessel 1. The solid state device 24 is attached to the vessel 1 in a manner that the rear side of the carrier 7 behind the semiconductor chip 8 faces the bottom opening 47 of the vessel 1. A radiator 21 is attached to the rear surface of the carrier 7. With this construction, only the portion around the heat generative part contacts with the coolant to effectively cool the solid state device with small amount of coolant. Thereby, the overall structure becomes small. The effect of preventing amplitude modulation is similarly obtained as the examples of Figs. 1 to 9, since the semiconductor chip 8 does not directly contact the liquid coolant.

Another embodiment of the present invention is illustrated in Fig. 22. A plurality of conical wave absorbers 51 are attached to a support plate 50 which is secured to the coolant vessel 1. The wave absorbers 51 are disposed above the solid state device 24 to be cooled, so that leakage waves leaked from the solid state circuit are absorbed and prevented from being reflected by bubbles or liquid surface. The amplitude modulation due to the bubbles is minimized, accordingly.

The shape of the wave absorber 51 is not limited to the conical shape. The shape, size, number and position of the wave absorbers 51 are determined according to the size and characteristic of the solid state circuit. The wave absorbers 51 may be directly attached to the lower side of the upper plate 3 of the vessel 1, as illustrated in Fig. 23.

Another variation of solid state device is illustrated in Fig. 24. A plurality of wave absorbers 51 are attached to two upper plates 52 which are secured to the walls 7a of the carrier 7.

A variation of the embodiment of Fig. 22 is illustrated in Fig. 25. In this example, heat absorbing fins 53 are formed below the upper plate 3 for promoting condensation of the coolant vapor. A wave absorber layer 54 covers the surface of the fins 53.

Fig. 26 represents another arrangement of the wave absorber. A wave absorber 51 is secured to the lower end of each heat absorbing fin 53.

Fig. 27 represents an arrangement in which a plurality of solid state devices are disposed in a coolant vessel, in accordance with the present invention. A plurality of solid state devices 24 are disposed in two rows, i.e., upper row and lower row, in a staggered manner, so that the bubbles generated from the solid state device in the lower row do not contact with the solid state devices in the upper row, in the upward movement thereof, thereby preventing the amplitude modulation due to the bubbles.

Fig. 28 represents another arrangement of a plurality of the solid state devices in accordance with the present invention. A plurality of solid state devices 24 are disposed radially. An input coaxial cable 11a of each solid state device 24 is connected to a distributer 61 and an output coaxial cable 11b of each solid state device 24 is connected to a coupler 60. Each of the coupler 60 and the distributer 61 is connected to the outside device (not shown) through a coaxial cable 62.

With this arrangement, bubbles 14 generated from each solid state device 24 do not contact with the other solid state devices 24. Solid state devices 24 can be disposed close together, since cooling efficiency is upgraded, as mentioned above, in accordance with the various embodiments of the invention. Therefore, the coaxial cables 11a, 11b can be shortened, which results in increase of coupling efficiency and the coolant vessel become small. Also, the length of each cable connected to each solid state device is equalized, which results in equality of characteristic of each solid state device.

Fig. 29 represents another arrangement of a plurality of solid state devices. A plurality of solid state devices 24 are disposed annularly in a manner that the connecting points of the cable 11 of solid state devices 24 are positioned on a same circle and at regular intervals. Each solid state device 24 is inclined in the liquid coolant 2, as illustrated in Fig. 30. With such an inclined arrangement of each solid state device, when bubbles from the lower solid state device contact with the under surface of the upper solid state device, the bubbles smoothly move along the inclined under surface of the upper solid state device and do not stay there.

In the arrangement of a small number of solid state devices, it is desirable to dispose the solid state devices 24 in a staggered manner with respect to vertical direction, so that bubbles from a lower solid state device do not contact with an upper solid state devices, as illustrated in Fig. 31.

Another arrangement of a plurality of solid state devices is illustrated in Figs. 32 to 34, which represent a vertical section, a horizontal section and an upper view of the structure, respectively. The coolant vessel 1 has a shape of polygonal pillar. A solid state device 24 is attached to the inside surface of each side wall of the polygonal pillar shaped vessel 1. The solid state device 24 is, e.g., of the type of Fig. 5 or 6. The radiator 21 of the solid state device 24 (Figs. 5 and 6) is oriented toward inner side of the vessel 1. Radiator fins 63 are provided on the outside surface of each side wall of the vessel 1. The coupler 60 is disposed on the upper side of the upper plate 3 and the distributer 61 is disposed on the lower side of the bottom plate of the vessel 1. Radiator fins 64 are also provided on the outside surface of the bottom plate of the vessel 1.

With this construction, the cooling efficiency is enhanced because of the radiator fins 63 and 64, which enables a more compact arrangement of solid state devices. Also, means for sealing the coupler 60 and the distributer 61, respectively, are not required, since they are disposed on the outside of the vessel 1.

In the drawings of the above-mentioned various embodiments, the same parts or corresponding parts are marked by the same number and the description of the part is deleted.

It is, of course, possible to combine any parts of any embodiments together with other parts of other embodiments of the invention to constitute another embodiment of the invention as claimed.

Claims

1. A liquid cooling type high frequency solid state device arrangement comprising a solid state chip (8); at least one matching circuit (6) connected to said solid state chip (8); a carrier (7) for mounting said solid state chip (8) and said matching circuit (6), constituting a solid state device (24) to be cooled; a coolant vessel (1) for containing a liquid coolant (2), a space for coolant vapor remaining at the top thereof; and a means (4) for condensing said coolant vapor contained in the top space of said vessel (1), heat radiation means

(15, 33, 39) having a surface area in contact with said liquid coolant (2) considerably greater than area of said chip (8) and being in contact with at least a part of said solid state device (24) for boiling and evaporating said coolant, and electromagnetic wave leakage suppression means (34, 41, 51, 54).

2. An arrangement according to claim 1 characterized in that said solid state chip (8) is prevented from coming in direct contact with said liquid coolant (2).

3. An arrangement according to claim 2 characterized in that: said heat radiation means is formed from a mount (15), said solid state chip (8) is secured on said mount (15); a recess (9) is formed in said carrier (7), opening in the upper surface of said carrier; said solid state chip (8) is disposed in said recess (9) of said carrier (7); and said recess is sealed by said mount (15).

4. An arrangement according to claim 3 characterized in that said solid state chip (8) on said mount (15) is sealed by a package (16) which is buried in said carrier (7).

5. An arrangement according to claim 2 characterized in that said solid state chip (8) is secured on a mount (15) and sealed by a package (30); and said mount (15) is secured to the upper side of said carrier (7) in a manner that the package (30) is disposed on the upper side of said mount (15).

6. An arrangement according to claims 4 and 5 characterized in that said electromagnetic wave leakage suppression means (17; 34) is provided on said package (16; 30).

7. An arrangement according to claims 3, 4 or 6 characterized in that said heat radiation means (19) is provided on the rear surface of said mount (15).

8. An arrangement according to claim 1 characterized in that said matching circuit is formed as a triplate type matching circuit (25) comprising an assembly of two dielectric layers (26, 27) between which matching circuit patterns are disposed and an upper and a lower conductive layers (28, 29) disposed on the upper and lower sides of said assembly.

9. An arrangement according to claim 1 characterized in that said matching circuit (35) is formed as a lumped elements type matching circuit.

10. An arrangement according to claim 1 characterized in that said solid state chip (8) is directly mounted on said carrier (7, 40); said heat radiation means (39) are disposed on both sides of and adjacent to said solid state chip (8); and said electromagnetic wave leakage suppression means includes two parallel metallic bars (41), provided for preventing the wave leakage from said matching circuit (6), the distance between said two bars being equal to a cut-off dimension (W), said cut-off dimension being less than one half of the wavelength of the operating frequency of the device.

11. An arrangement according to claim 1 characterized in that said electromagnetic wave leakage suppression means (51, 54) is provided above said carrier (7) of said solid state device (8) which is disposed in said coolant vessel (1). (Figs. 22 to 25).

12. An arrangement according to claim 1 characterized in that a plurality of said solid state devices (24) are disposed in an upper and a lower row in a staggered manner in said liquid coolant (2). (Fig. 27).

13. An arrangement according to claim 1 characterized in that a plurality of said solid state devices (24) are radially disposed in said liquid coolant (2). (Fig. 28).

14. An arrangement according to claim 1 characterized in that a plurality of said solid state devices (24) are disposed in said liquid coolant (2) in a manner that the bottom surface of each solid state device (24) is inclined (Figs. 30 & 31) to the horizontal.

15. An arrangement according to claim 1 characterized in that a radiator means (63) is provided on the outer side surface of said vessel (1); and said solid state device (24) is attached to the inner side surface of said vessel (1) (Figs. 32, 33 & 34).

Patentansprüche

1. Hochfrequenz-Festkörperanordnung vom flüssigkeitsgekühlten Typ, umfassend einen Festkörperchip (8); mindestens eine Anpassungsschaltung (6), die mit dem Festkörperchip (8) verbunden ist; einen Träger (7) zum Befestigen des besagten Festkörperchip (8) und der besagten Anpassungsschaltung (6), der eine zu kühlende Festkörpervorrichtung (24) bildet; ein Kühlmittelgefäß (1) zum Aufnehmen eines flüssigen Kühlmittels (2), wobei im oberen Bereich ein Raum für Kühlmitteldampf verbleibt; und eine Einrichtung (4) zum Kondensieren des besagten Kühlmitteldampfes, der im oberen Raum des besagten Gefäßes (1) enthalten ist, eine Wärmestrahlungseinrichtung (15, 33, 39) mit einem in Kontakt mit dem flüssigen Kühlmittel stehenden Oberflächenbereich, der wesentlich größer ist als der Bereich des Chip (8) und mit mindestens einem Teil der besagten Festkörpervorrichtung (24) in Kontakt ist zum Sieden und Verdampfen des besagten Kühlmittels, und eine Einrichtung (34, 41, 51, 54) zum Unterdrücken von Streuung elektromagnetischer Wellen.

2. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß der besagte Festkörperchip (8) davor geschützt ist, in direkten Kontakt mit dem flüssigen Kühlmittel (2) zu gelangen.

3. Anordnung nach Anspruch 2, dadurch gekennzeichnet, daß: die besagte Wärmestrahlungseinrichtung durch eine Halterung (15) gebildet ist, wobei der Festkörperchip (8) auf der besagten Halterung (15) befestigt ist; in dem besagten Träger (7) eine Ausnehmung (9) gebildet ist, die sich in der oberen Fläche des besagten Trägers öffnet; der besagte Festkörperchip (8) in der besagten Ausnehmung (9) des besag-

ten Trägers (7) angeordnet ist; und die besagte Ausnehmung durch die besagte Halterung (15) abgedichtet ist.

4. Anordnung nach Anspruch 3, dadurch gekennzeichnet, daß der besagte Festkörperchip (8) auf der Halterung (15) durch eine Packung (16) abgedichtet ist, die in dem Träger (7) versenkt angeordnet ist.

5. Anordnung nach Anspruch 2, dadurch gekennzeichnet, daß der besagte Festkörperchip (8) auf einer Halterung (15) befestigt und durch eine Packung (30) versiegelt ist; und die besagte Halterung (15) auf der oberen Seite des besagten Trägers (7) derart befestigt ist, daß die packung (30) auf der oberen Seite der besagten Halterung (15) angeordnet ist.

6. Anordnung nach den Ansprüchen 4 und 5, dadurch gekennzeichnet, daß der besagte Einrichtung (17; 34) zum Unterdrücken von Streuung elektromagnetischer Wellen auf der besagten Packung (16; 30) vorgesehen ist.

7. Anordnung nach den Ansprüchen 3, 4 oder 6, dadurch gekennzeichnet, daß die besagte Wärmestrahlungseinrichtung (19) zum Unterdrücken von Streuung elektromagnetischer Wellen auf der hinteren Fläche der besagten Halterung (15) vorgesehen ist.

8. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß die besagte Anpassungsschaltung als eine Anpassungsschaltung (25) vom Triplet-Typ ausgebildet ist, umfassend einen Aufbau von zwei dielektrischen Schichten (26, 27), zwischen denen Anpassungsschaltungsmuster angeordnet sind, und von einer oberen und unteren leitenden Schicht (28, 29), die auf den oberen und unteren Seiten des besagten Aufbaus angeordnet sind.

9. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß die besagte Anpassungsschaltung (35) als eine Anpassungsschaltung vom Typ mit diskreten Schaltungselementen ausgebildet ist.

10. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß der besagte Festkörperchip (8) unmittelbar auf dem Träger (7, 40) befestigt ist; die besagte Wärmestrahlungseinrichtung (39) auf beiden Seiten des Festkörperchips (8) in dessen Nähe angeordnet ist; und die Einrichtung zum Unterdrücken von Streuung elektromagnetischer Wellen zwei parallele metallische Stangen (41) umfaßt, die zur Verhinderung der Streuung von Wellen von der besagten Anpassungsschaltung (6) vorgesehen sind, wobei der Abstand zwischen den zwei Stangen gleich ist einer Abschirmdimension (W), welche kleiner ist als eine Hälfte der Wellenlänge der Betriebsfrequenz der Vorrichtung.

11. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß die besagte Einrichtung (51, 54) zum Unterdrücken von Streuung elektromagnetischer Wellen über dem Träger (7) der Festkörpervorrichtung (8) vorgesehen ist, welche in dem besagten Kühlflüssigkeitsgefäß (1) angeordnet ist (Fig. 22 bis 25).

12. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß eine Anzahl von besagten Festkörpervorrichtungen (24) in einer oberen und unteren Reihe gegeneinander versetzt in dem besagten flüssigen Kühlmittel (2) angeordnet ist (Fig. 27).

13. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß eine Anzahl von besagten Festkörpervorrichtungen (24) radial in dem besagten flüssigen Kühlmittel (2) angeordnet ist (Fig. 28).

14. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß eine Anzahl von besagten Festkörpervorrichtungen (24) in dem besagten flüssigen Kühlmittel (2) darart angeordnet ist, daß die untere Fläche einer jeden Festkörpervorrichtung (24) zur Horizontalen geneigt ist (Fig. 30 und 31).

15. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß eine Radiatoreinrichtung (63) auf der außenseitigen Oberfläche des Gefäßes (1) vorgesehen ist und die Festkörpervorrichtung (24) an die innenseitige Oberfläche des Gefäßes (1) angesetzt ist (Fig. 32, 33 und 34).

Revendications

1. Une structure de dispositif à l'état solide de haute fréquence du type à refroidissement par liquide, comprenant: une puce à l'état solide (8); au moins un circuit d'adaptation (6) connecté à la puce à l'état solide (8); un support (7) pour permettre le montage de la puce à l'état solide (8) et du circuit d'adaptation (6), pour constituer ainsi un dispositif à l'état solide (24) à refroidir; une enceinte de fluide de refroidissement (1), destinée à contenir un fluide de refroidissement à l'état liquide (2), de façon qu'il reste au sommet de l'enceinte un espace pour la vapeur du fluide de refroidissement; et des moyens (4) pour condenser la vapeur de fluide de refroidissement qui est contenue dans l'espace supérieur de l'enceinte (1), des moyens de rayonnement de chaleur (15, 33, 39) ayant une aire de surface en contact avec le fluide de refroidissement à l'état liquide (2) considérablement supérieure à l'aire de la puce (8), et étant en contact avec au moins une partie du dispositif à l'état solide (24), pour provoquer l'ébullition et l'évaporation du fluide de refroidissement, et des moyens pour atténuer la fuite d'ondes électromagnétiques (34, 41, 51, 54).

2. Une structure selon la revendication 1, caractérisée en ce que la puce à l'état solide (8) ne peut pas venir en contact direct avec le fluide de refroidissement liquide (2).

3. Une structure selon la revendication 2, caractérisée en ce que: les moyens de rayonnement de chaleur sont formés à partir d'une plaque de montage (15) et la puce à l'état solide (8) est fixée sur cette plaque de montage (15); une cavité (9) est formée dans le support (7) et s'ouvre à la surface supérieure du support; la puce à l'état solide (8) est placée dans la cavité précitée (9) du support (7); et cette cavité est obturée par la plaque de montage (15).

4. Une structure selon la revendication 3,

caractérisée en ce que la puce à l'état solide (8) qui se trouve sur la plaque de montage (15) est enfermée hermétiquement dans un boîtier (16) qui est encastré dans le support (7).

5. Une structure selon la revendication 2, caractérisée en ce que la puce à l'état solide (8) est fixée sur une plaque de montage et est enfermée hermétiquement dans un boîtier (30); et cette plaque de montage (15) est fixée à la face supérieure du support (7) de manière que le boîtier (30) soit disposé sur la face supérieure de la plaque de montage (15).

6. Une structure selon les revendications 4 et 5, caractérisée en ce que les moyens d'atténuation de fuite d'ondes électromagnétiques (17; 34) sont placés sur le boîtier (16; 30).

7. Une structure selon les revendications 3, 4 ou 6, caractérisée en ce que les moyens de rayonnement de chaleur (19) sont placés sur la surface arrière de la plaque de montage (15).

8. Une structure selon la revendication 1, caractérisée en ce que le circuit d'adaptation est formé par un circuit d'adaptation du type triplaque (25) qui comprend un assemblage de deux couches diélectriques (26, 27) entre lesquelles se trouvent des motifs de circuit d'adaptation, et des couches conductrices supérieure et inférieure (28, 29) disposées sur les faces supérieure et inférieure de l'assemblage précité.

9. Une structure selon la revendication 1, caractérisée en ce que le circuit d'adaptation (35) est formé par un circuit d'adaptation du type à éléments discrets.

10. Une structure selon la revendication 1, caractérisée en ce que la puce à l'état solide (8) est directement montée sur le support (7, 40); les moyens de rayonnement de chaleur (39) sont disposés sur les deux faces de la puce à l'état solide (8), et dans des positions adjacentes à cette dernière; et les moyens d'atténuation de fuite d'ondes électromagnétiques comprennent deux barres métalliques parallèles (41), formées de façon à empêcher la fuite d'ondes à partir du circuit d'adaptation (6), la distance entre ces deux barres étant égale à une dimension de coupure (W), et cette dimension de coupure étant inférieure à la moitié de la longueur d'onde qui correspond à la fréquence de fonctionnement du dispositif.

11. Une structure selon la revendication 1, caractérisée en ce que les moyens d'atténuation de fuite d'ondes électromagnétiques (51, 54) sont formés au-dessus du support (7) du dispositif à l'état solide (8) qui se trouve dans l'enceinte de fluide de refroidissement (1). (figures 22 à 25).

12. Une structure selon la revendication 1, caractérisée en ce qu'un ensemble de dispositifs à l'état solide (24) sont disposés en une rangée supérieure et une rangée inférieure, de manière décalée, dans le fluide de refroidissement liquide (2) (figure 27).

13. Une structure selon la revendication 1, caractérisée en ce qu'un ensemble de dispositifs à l'état solide (24) sont disposés radialement dans le fluide de refroidissement liquide (2) (figure 28).

14. Une structure selon la revendication 1, caractérisée en ce qu'un ensemble de dispositifs à l'état solide (24) sont disposés dans le fluide de refroidissement liquide (2) de manière que la surface inférieure de chaque dispositif à l'état solide (24) soit inclinée par rapport à l'horizontale (figures 30 et 31).

15. Une structure selon la revendication 1, caractérisée en ce qu'un radiateur (63) est formé sur la surface latérale extérieure de l'enceinte (1); et le dispositif à l'état solide (24) est fixé sur la surface latérale intérieure de l'enceinte (1) (figures 32, 33 et 34).

Fig. 1

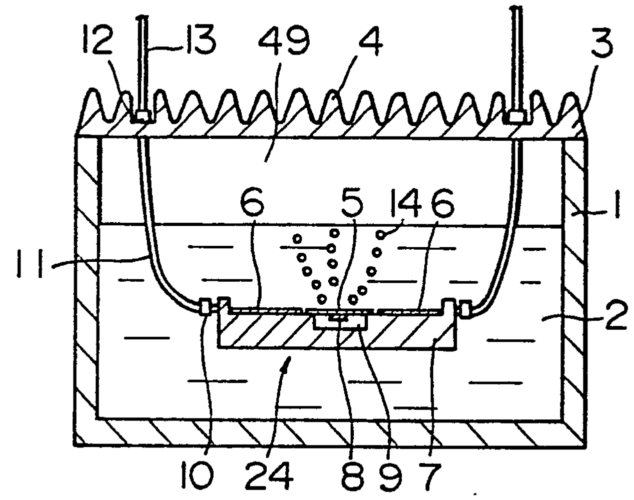


Fig. 2

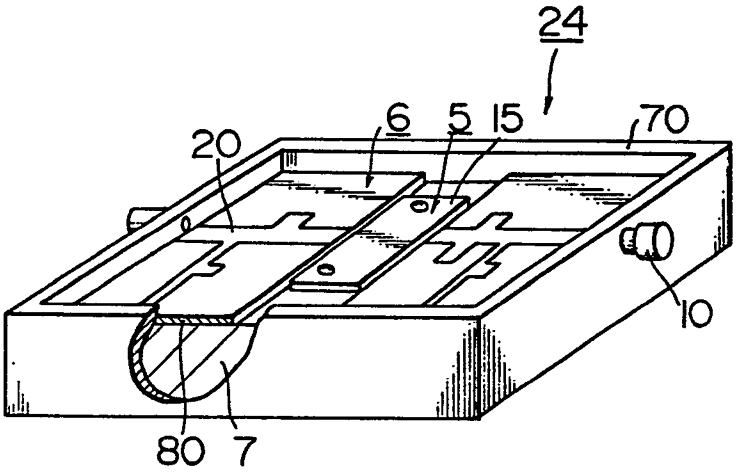


Fig.3

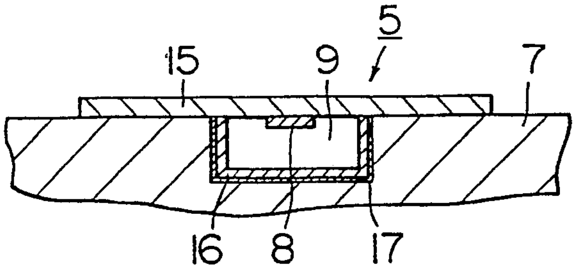


Fig.4

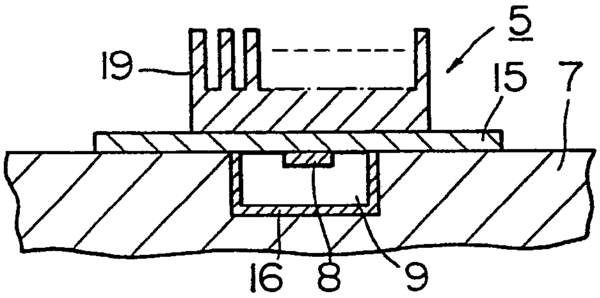


Fig.5

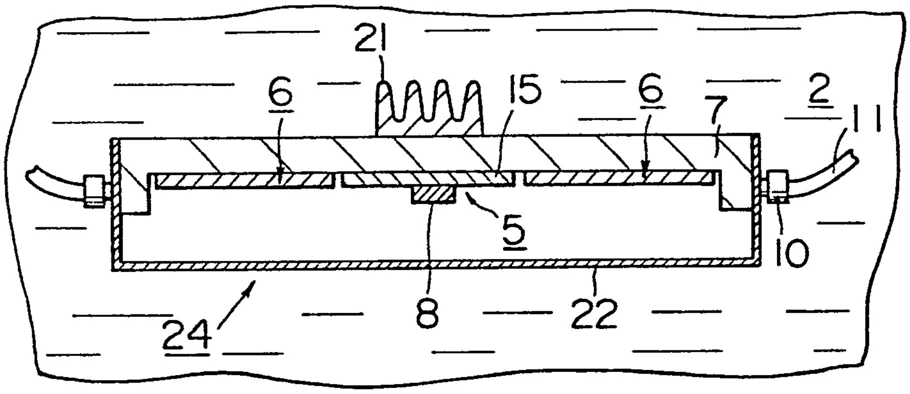


Fig.6

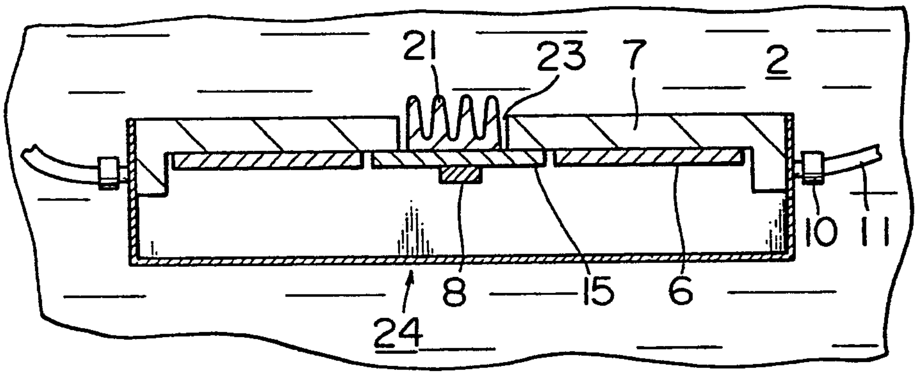


Fig.7

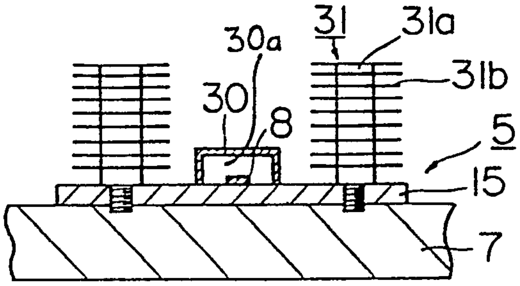


Fig.8

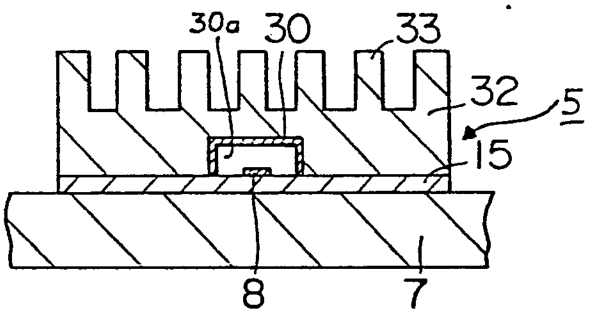


Fig.9

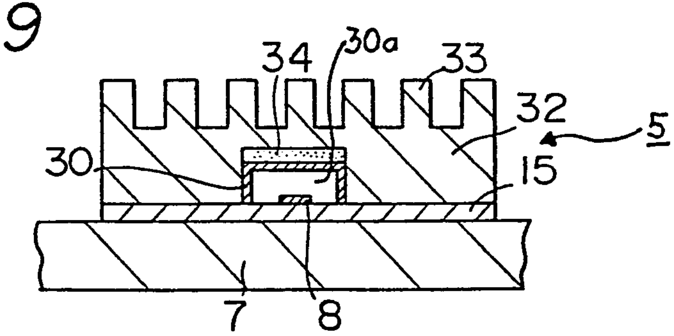


Fig.10

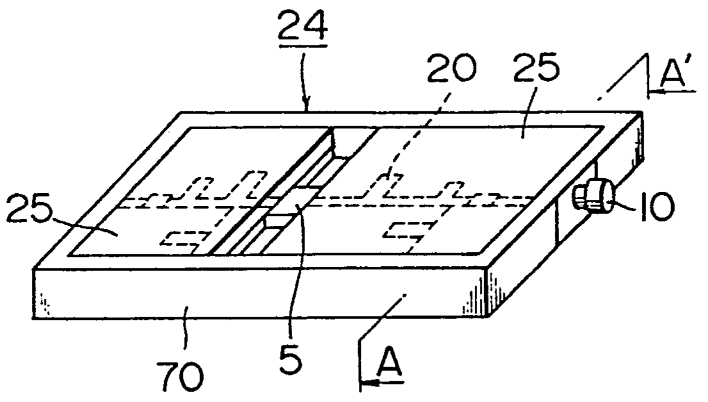


Fig.11

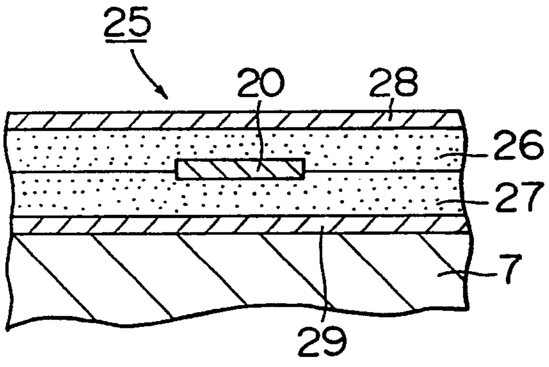


Fig. 12

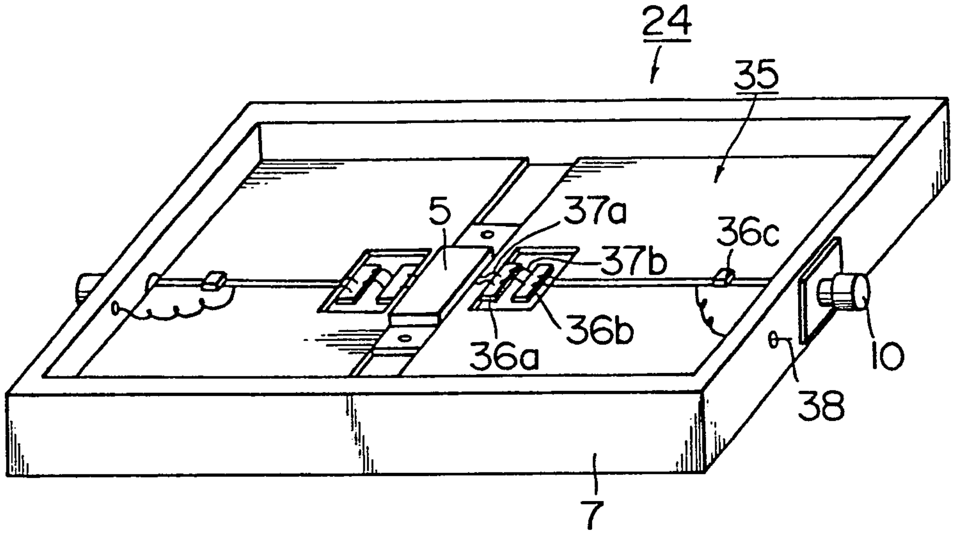


Fig. 13

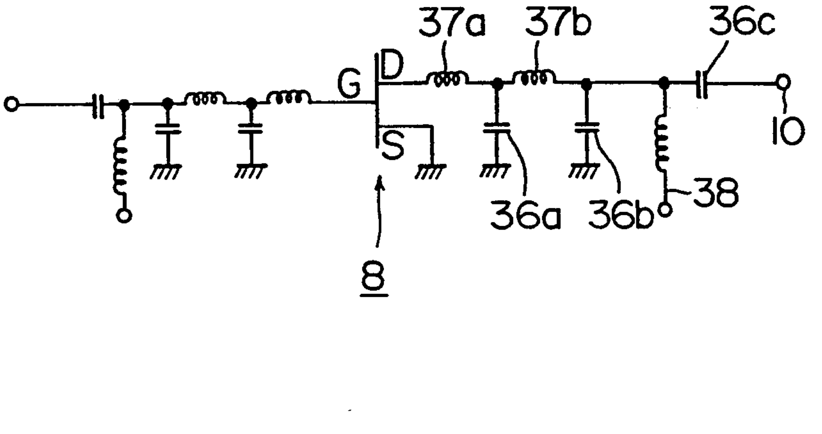


Fig.14

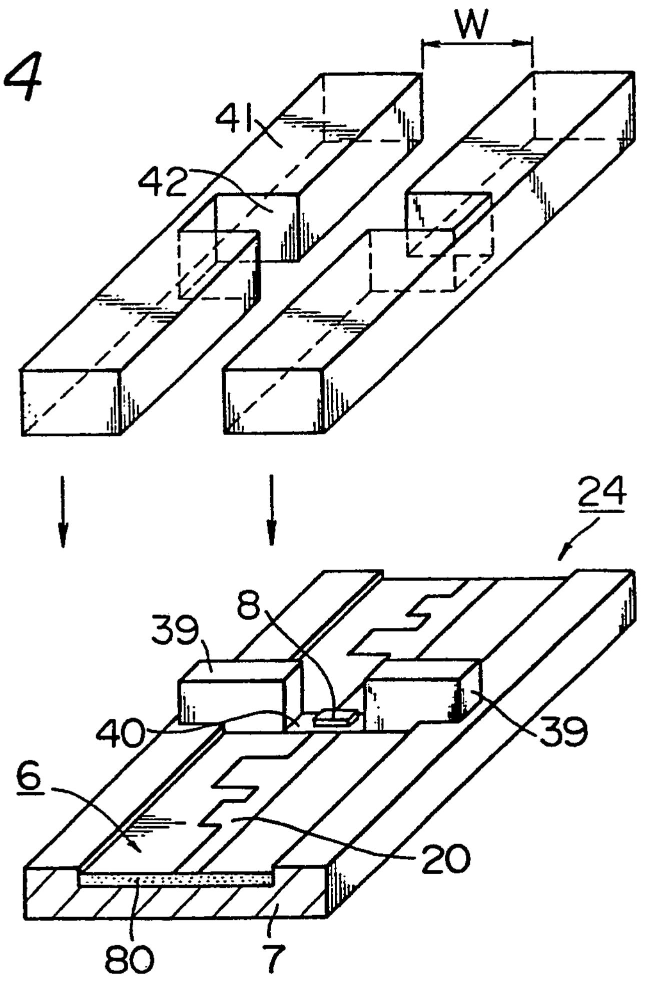


Fig.15

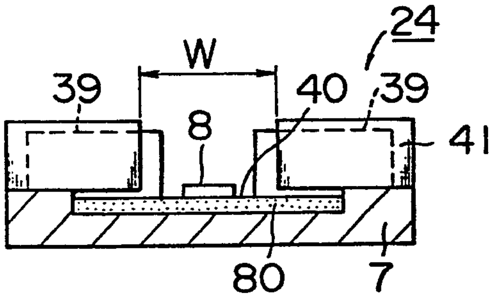
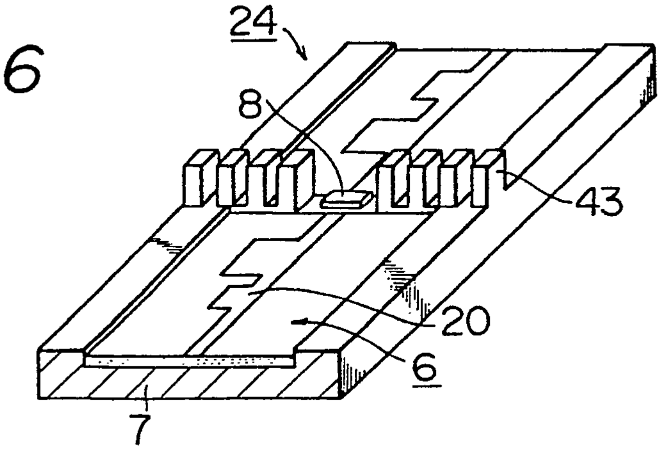


Fig.16



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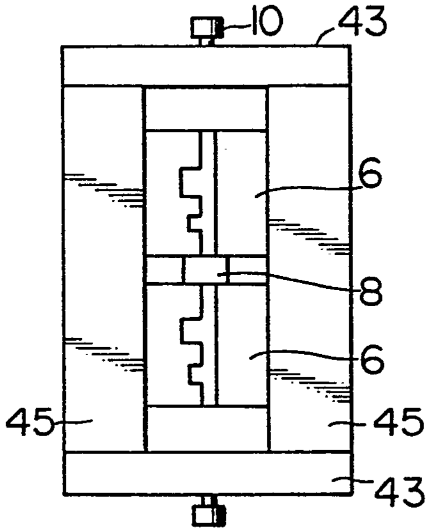

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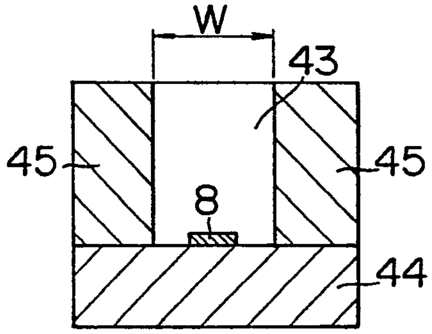

Fig.19

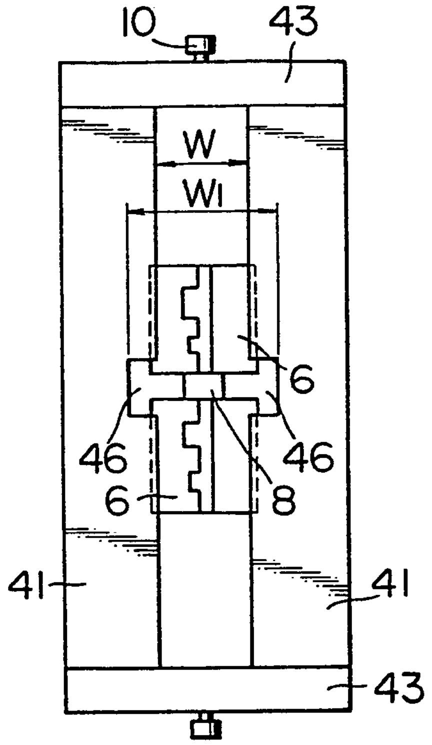

Fig.20

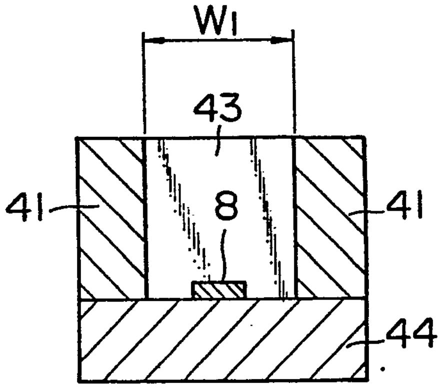

Fig. 21

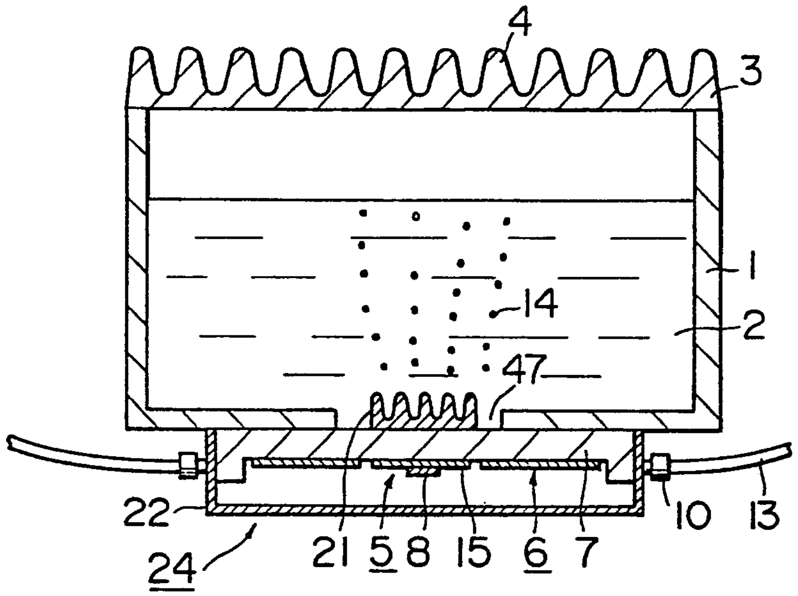

Fig. 22

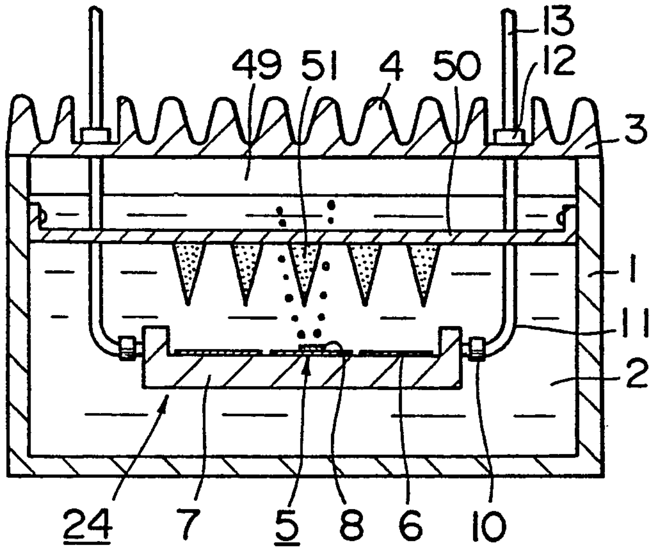

Fig.23

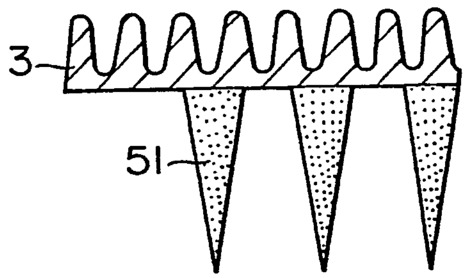

Fig.24

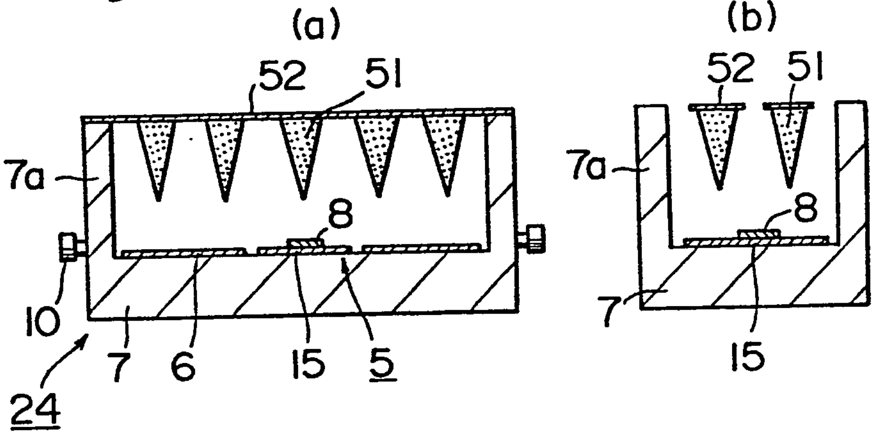

Fig.25

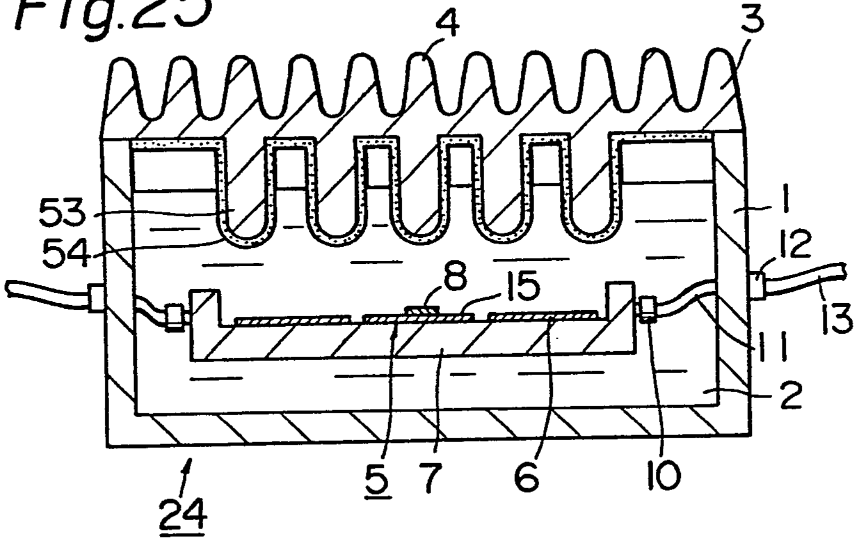

Fig. 26

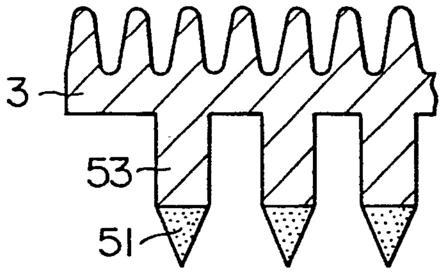

Fig. 27

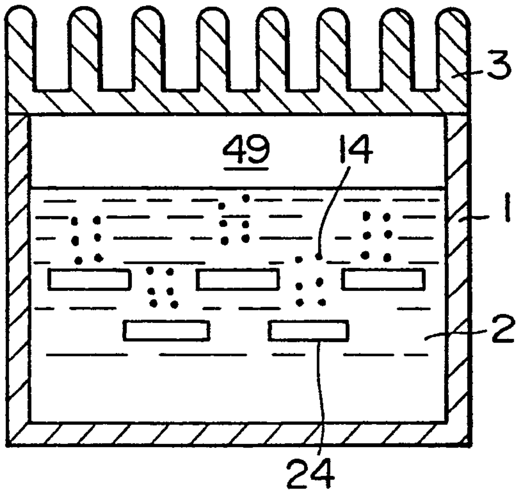

Fig.28

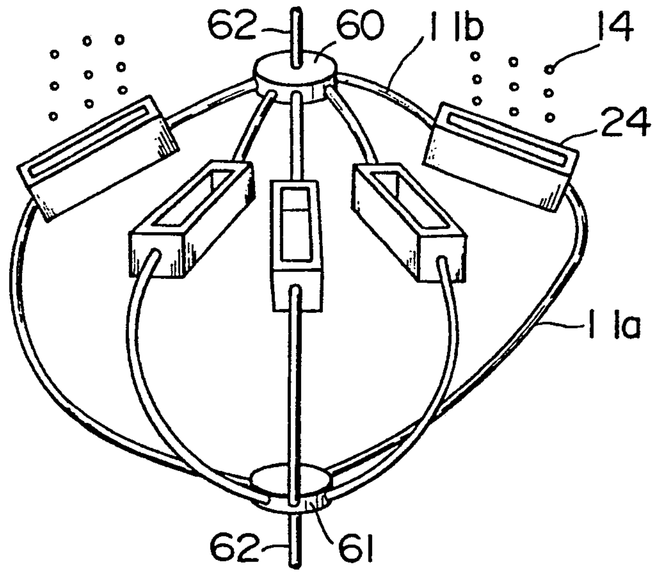

Fig.29

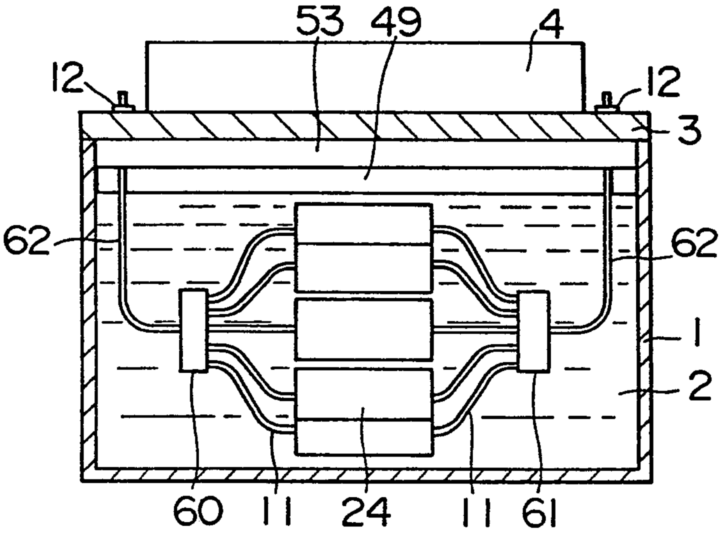

Fig.30

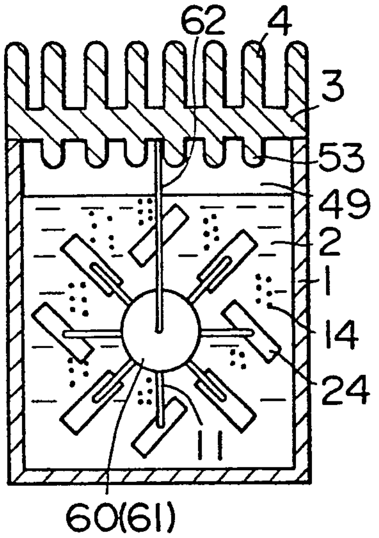

Fig.31

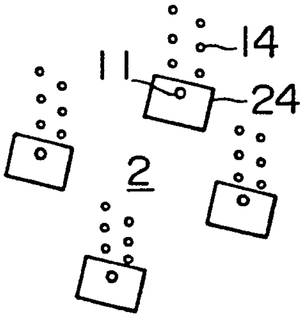

Fig.32

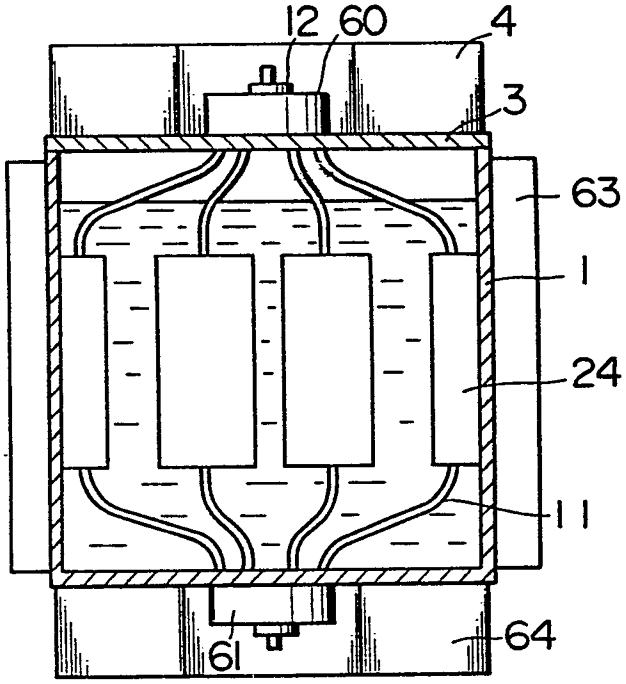

Fig.33

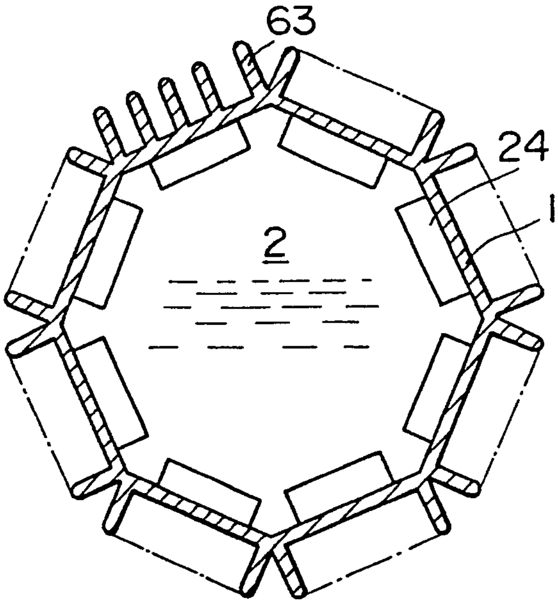

Fig.34